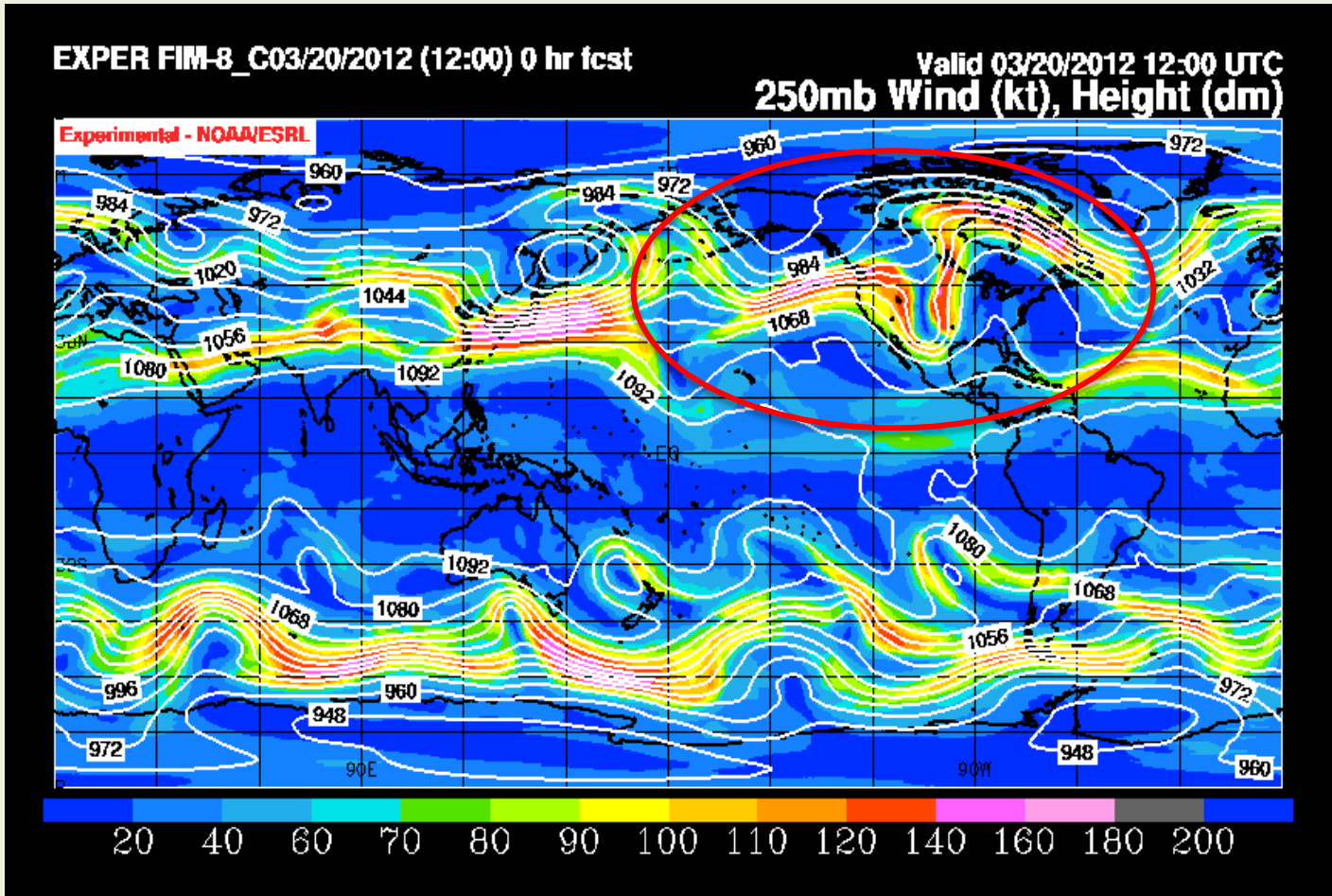
Episodic Weather Extremes

Longer-term weather anomalies from atmospheric blocking

-Defined here as either ridge or trough quasi-stationary events with duration of at least 4 days to 2+ months

ESPC demo target: improved 1-6 month forecasts of blocking and related weather extremes



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Episodic Weather Extremes

Longer-term weather anomalies from atmospheric blocking

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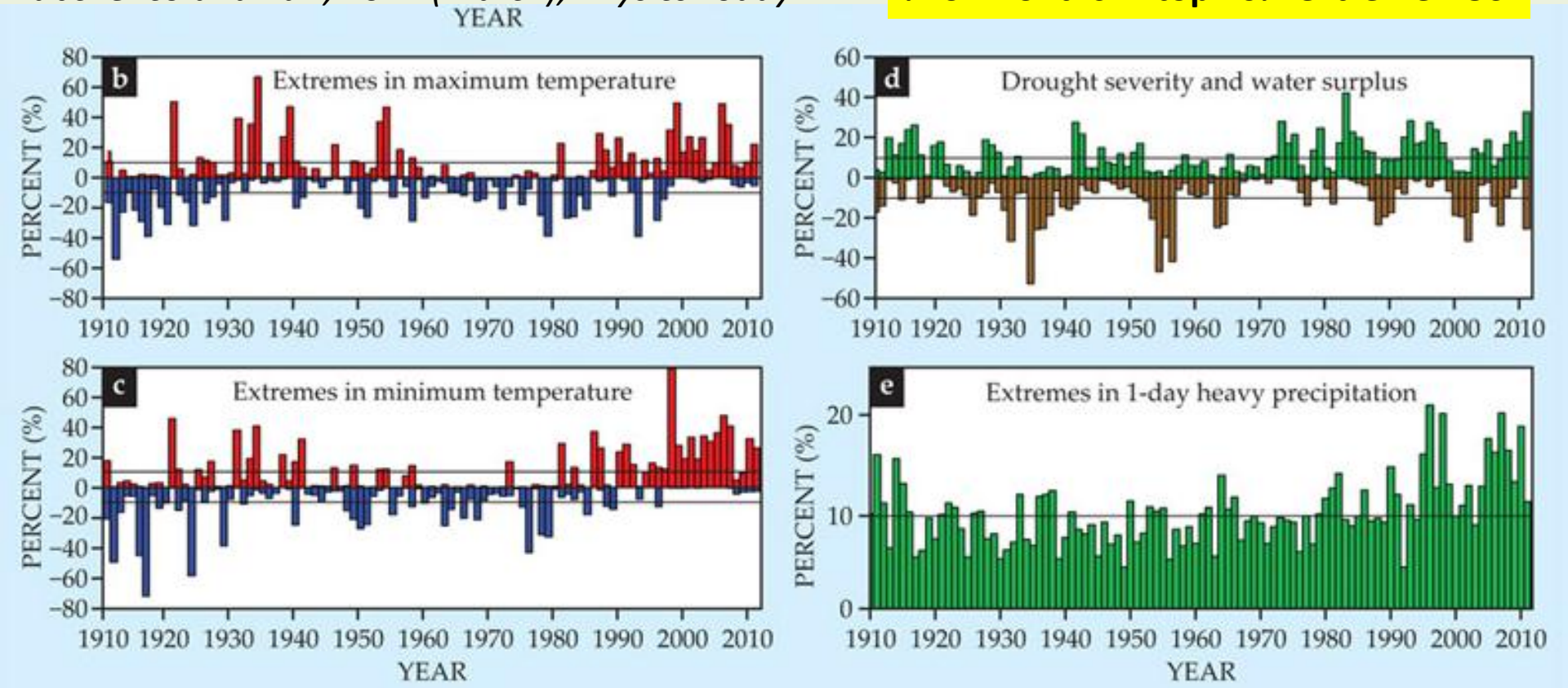
Lubchenco and Karl, 2012 (March), Physics Today

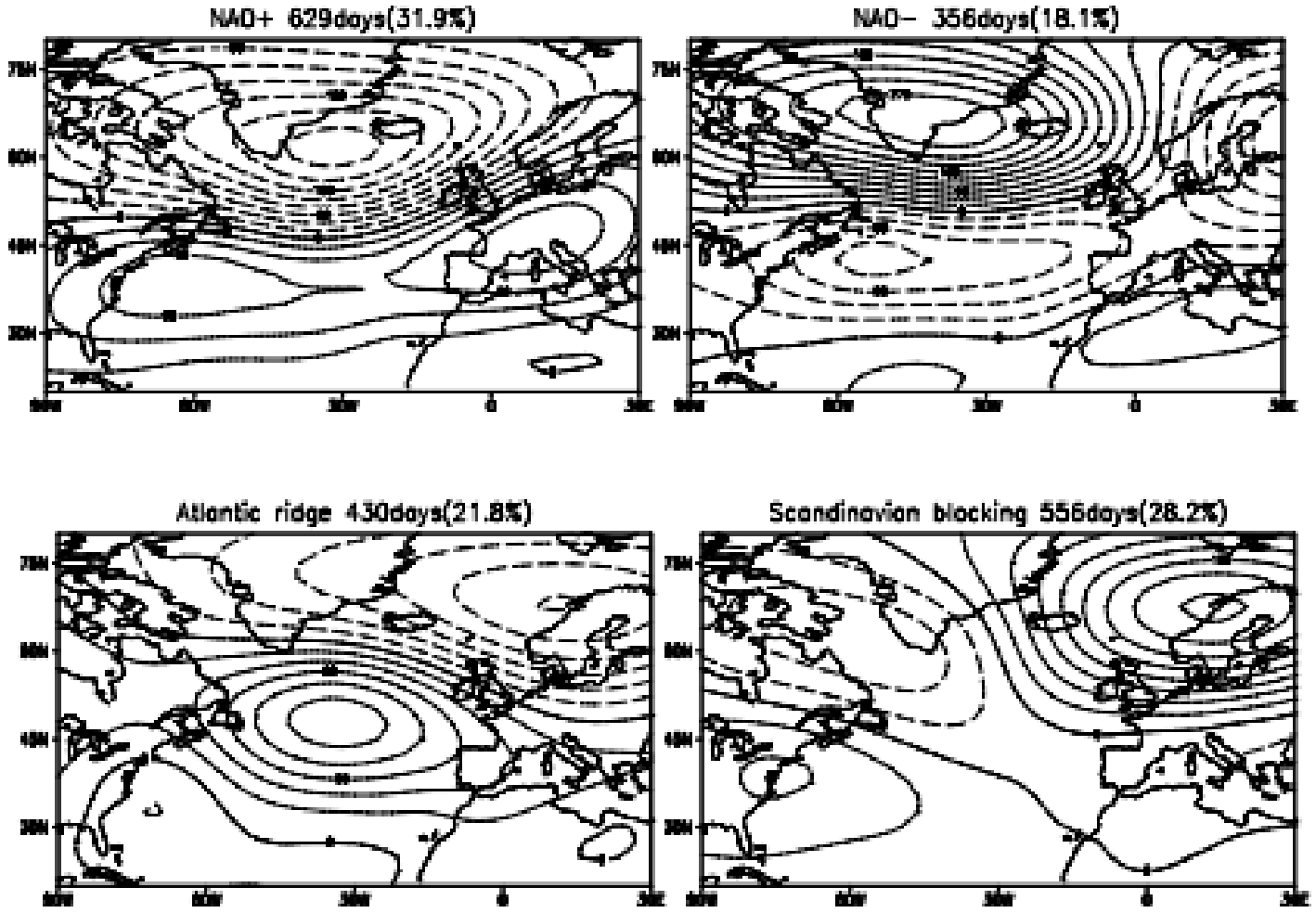
% of months in top 10% extreme - US



Possible causes of large-scale blocking episodes – onset or cessation

- MJO events
- Extratropical wave configurations
- Tropical cyclones with strong extratropical transition (NH fall only)
- Stratospheric sudden warming events
- Early season snow cover or melting

Classic patterns for NAO (+/-), Scandinavian block



Luo et al, 2012, J. Atmos. Sci. – Wx regime transition vs. NAO

Outcomes from prolonged blocking events or persistent anomalies

- Flooding
- Droughts, excessive fires
- Heat wave or cold wave
- Snow cover
- Excessive ice cover or absence of normal ice cover (example: Great Lakes – 2011-12 winter)
- Human and economic impact increases exponentially with duration of blocking event

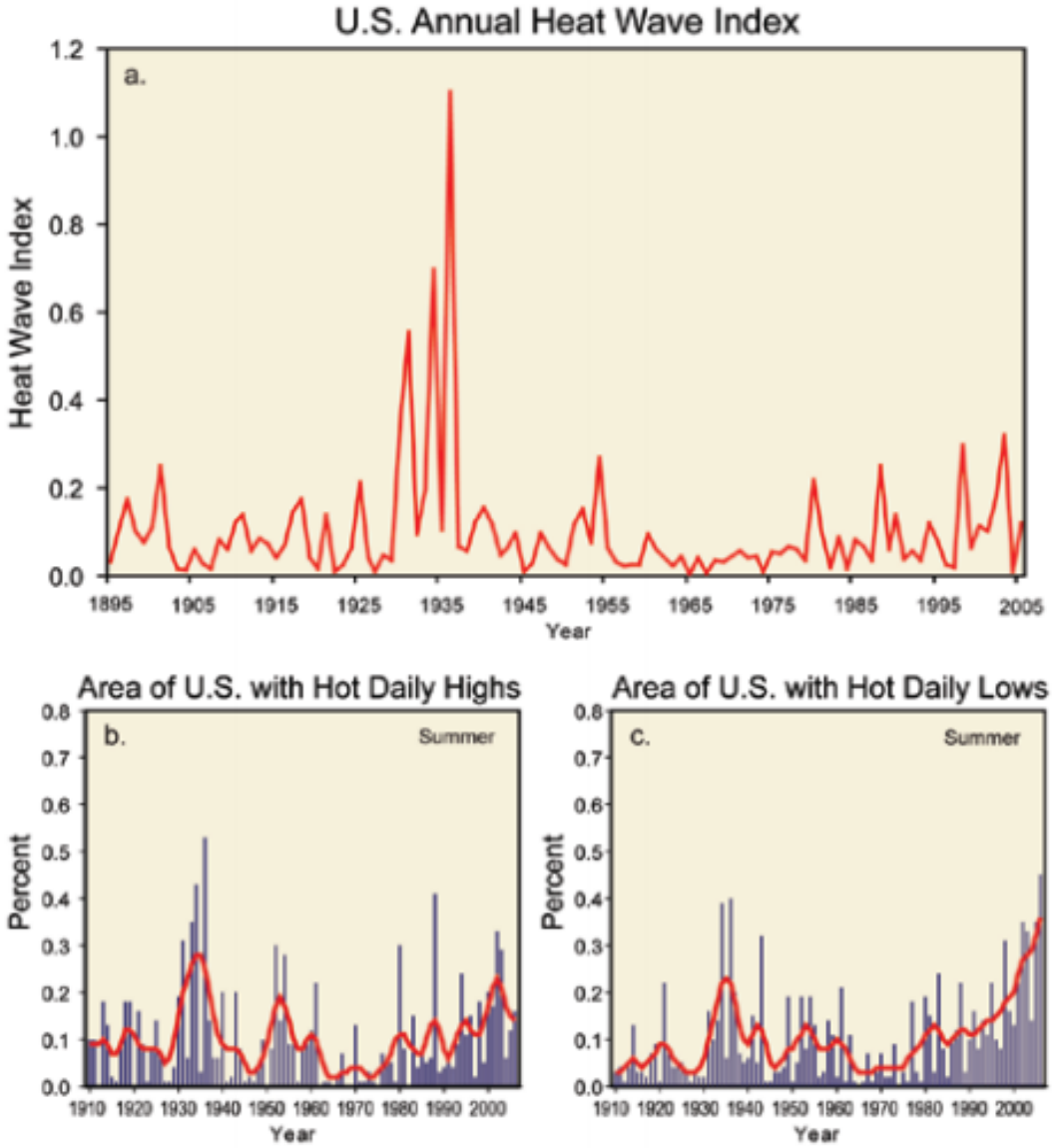
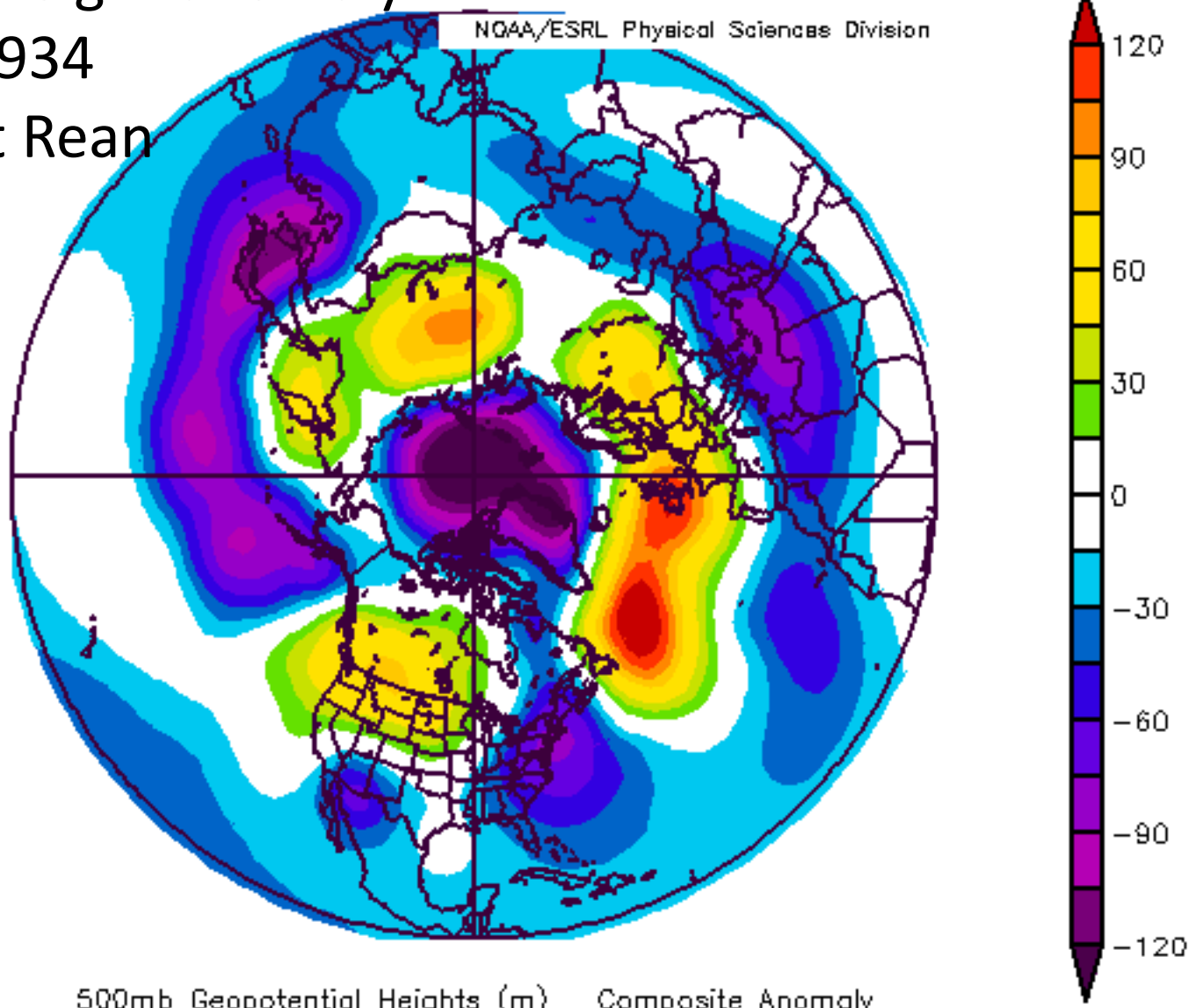
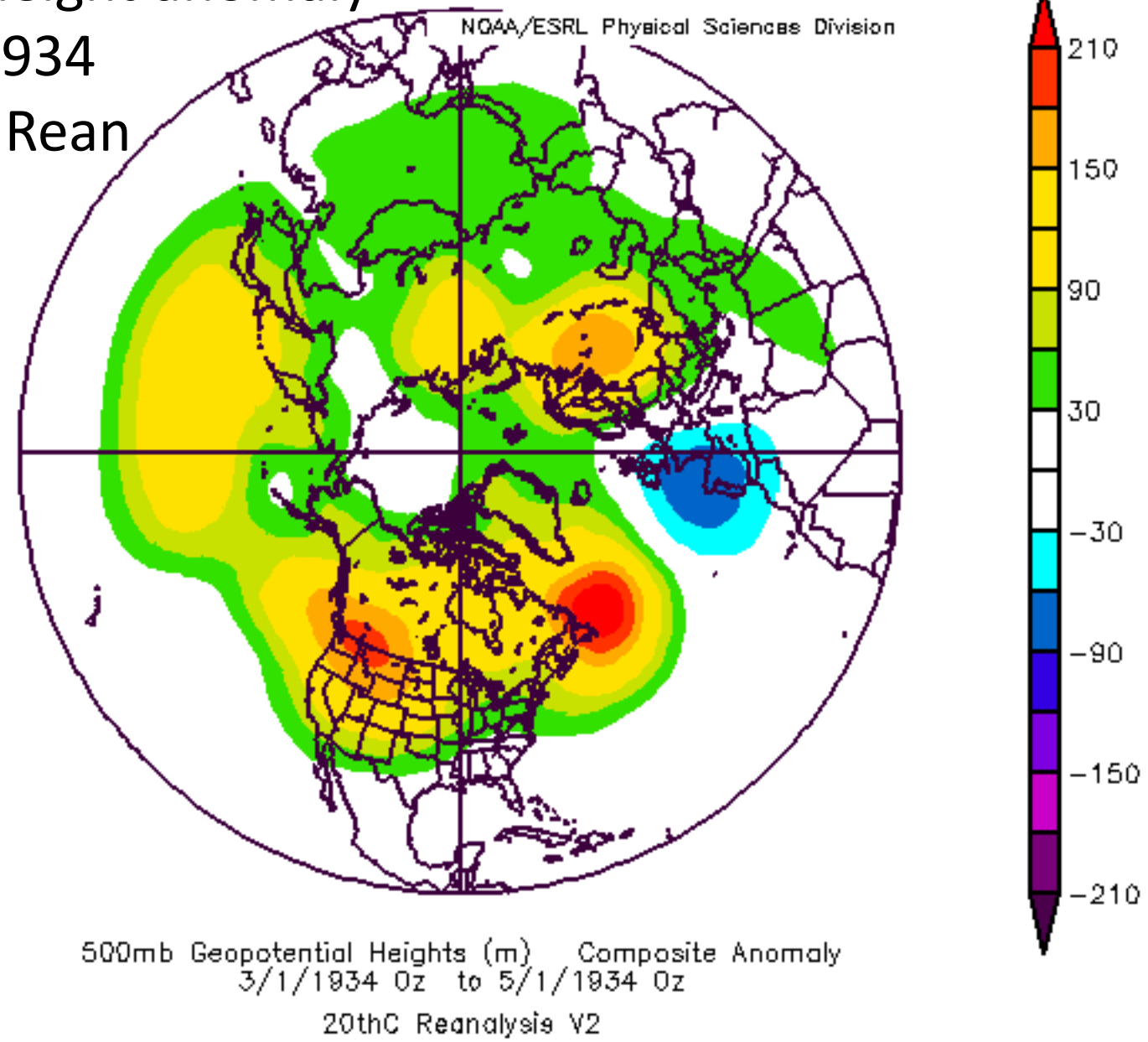


Figure 2.3 Time series of (a) annual values of a U.S. national average "heat wave" index. Heat waves are defined as warm spells of 4 days in duration with mean temperature exceeding the threshold for a 1 in 10 year event. (updated from Kunkel *et al.*, 1999); (b)Area of the United States (in percent) with much above normal daily high temperatures in summer; (c) Area of the United States (in percent) with much above normal daily low temperatures in summer. Blue vertical bars give values for individual seasons while red lines are smoothed (9-year running) averages. The data used in (b) and (c) were adjusted to remove urban warming bias.

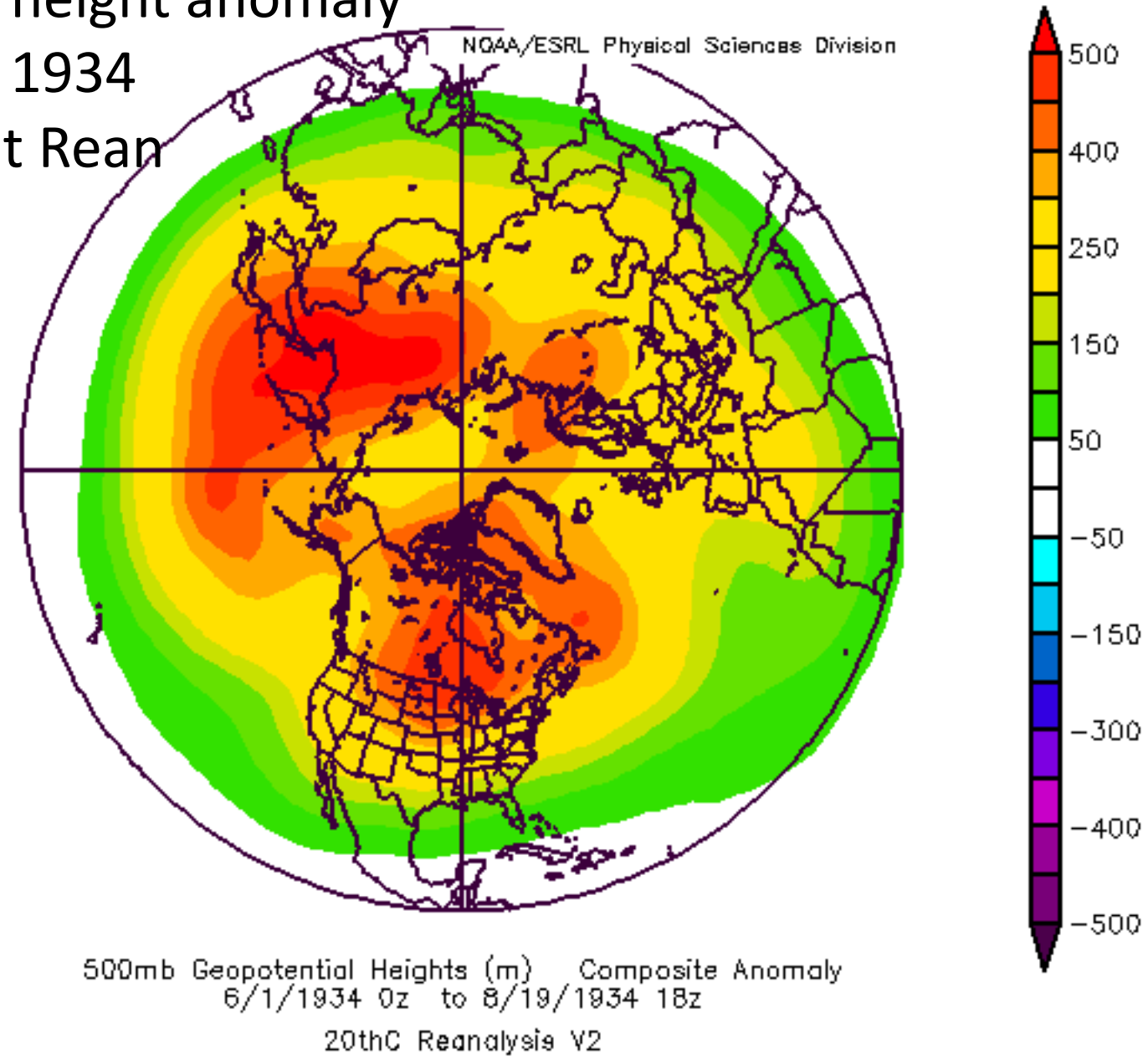
500 hPa height anomaly
JanFeb 1934
20th Cent Rean



500 hPa height anomaly
MarApr 1934
20th Cent Rean

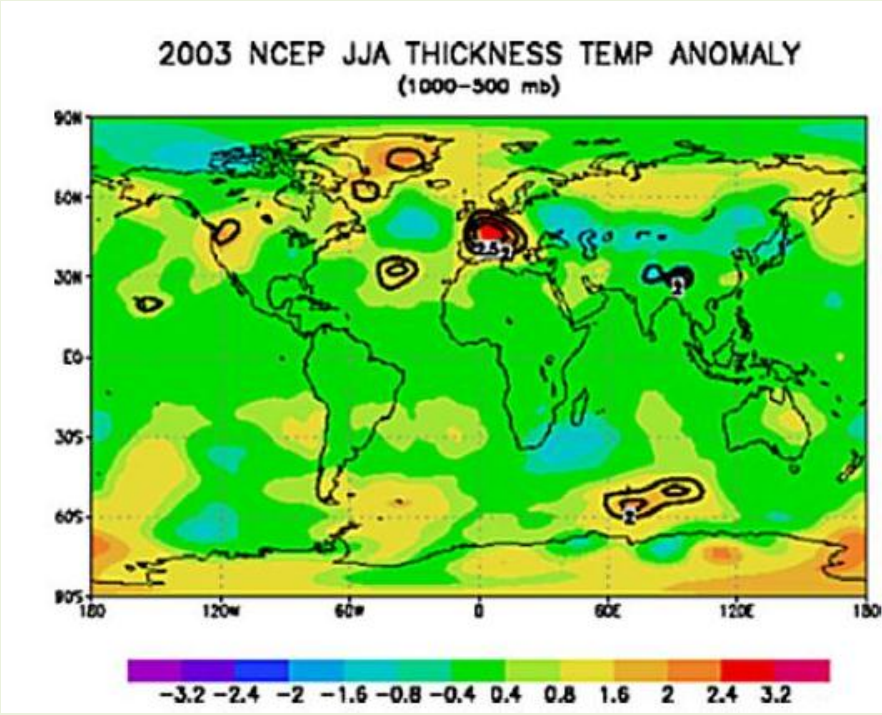


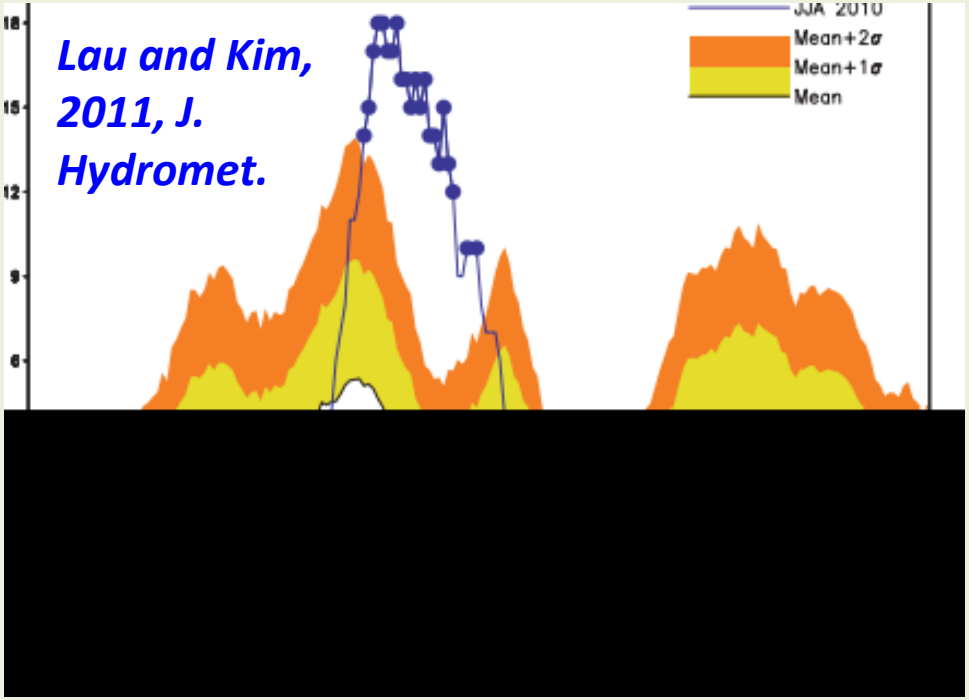
500 hPa height anomaly
Jun-Aug 1934
20th Cent Rean

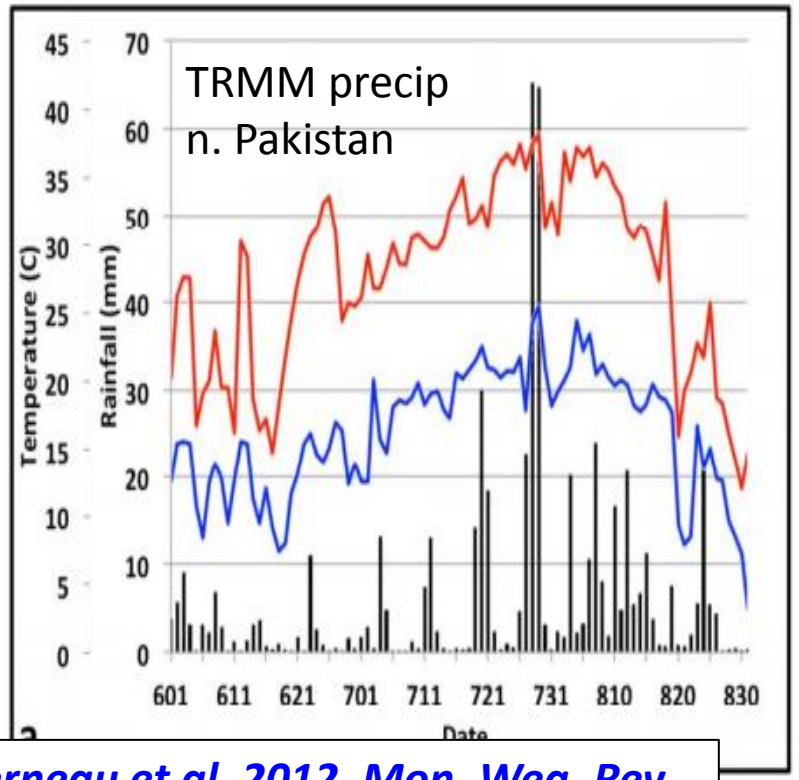


A very few of many notable weather events related to persistent blocks

- 1861-62 Great California Flood – (Dec-Feb)
- 1972 Iranian snowstorm – 3-9 Feb
  - Up to 26 feet
  - 4,000 deaths
- 2003 European heat wave
  - 15,000 deaths in France
- 2010 summer
  - Western Russia fires
  - Pakistan flooding



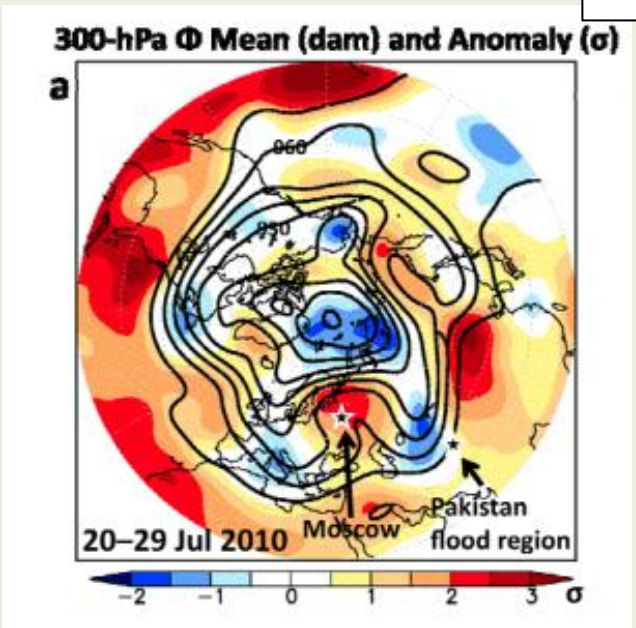


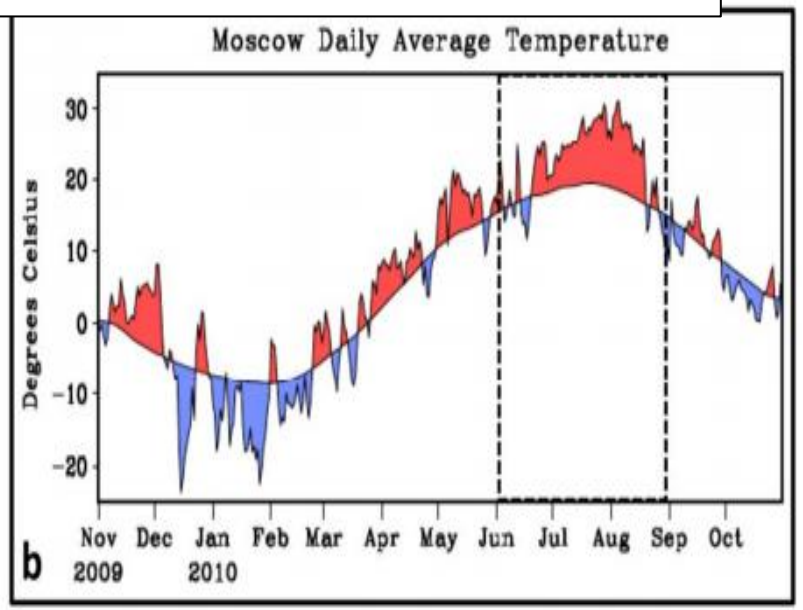


Galerneau et al. 2012, Mon. Wea. Rev.

2010 Jul-Aug

- Western Russia heat/fires
- Northern Pakistan - flooding

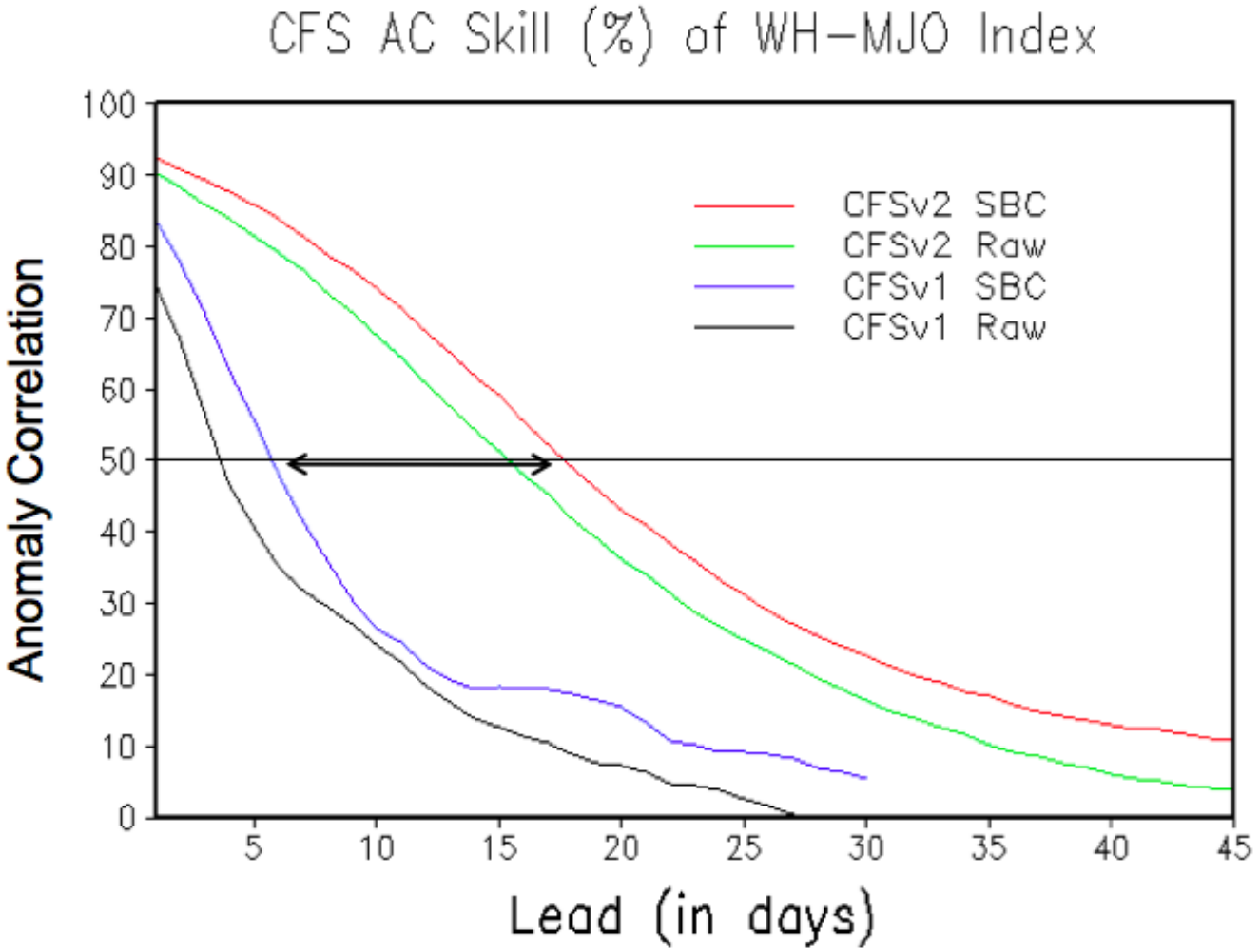




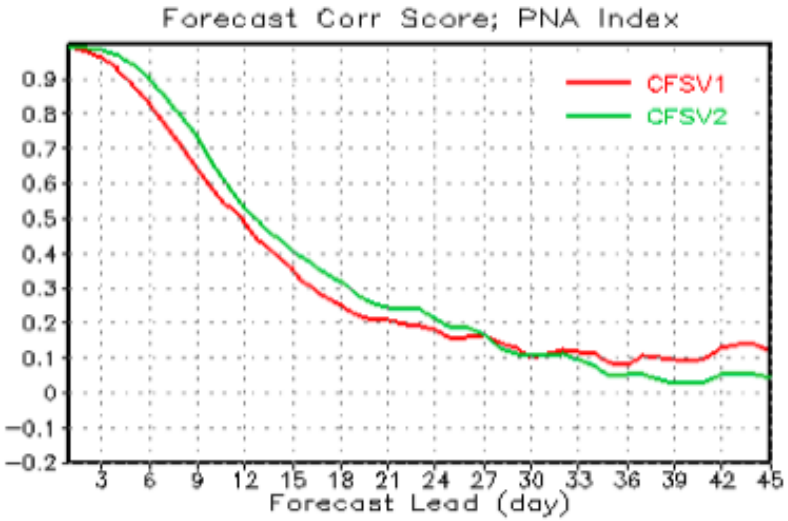
Climate Forecast System - NCEP

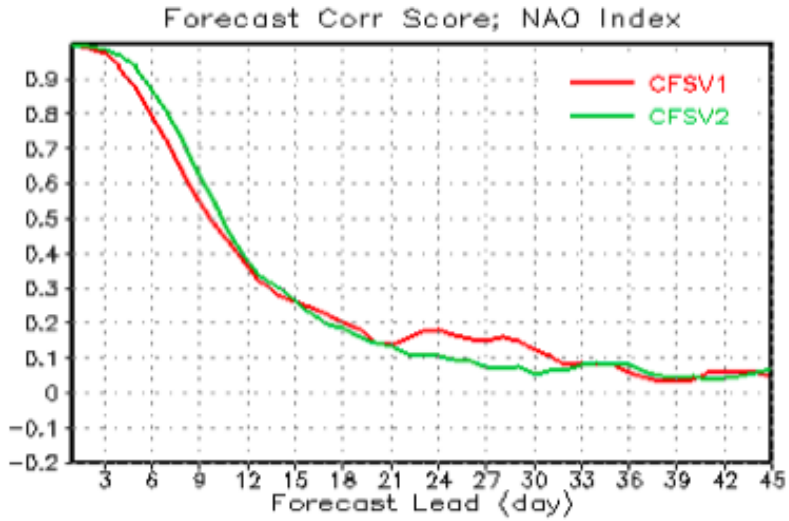
Attribute	CFS v1 (Operational Configuration)	CFS v2 Implemented March 2011
Analysis resolution	200 km (T62)	38 km (T382)
Atmosphere model - resolution	1995: 200 km / 28 levels	100km (T126) / 64 levs
Model physics	Humidity-based (diagnosed) clouds	Variable CO2 (specified) AER SW and LW radiation Prognostic clouds & liquid water Retuned mountain blocking Convective gravity wave drag
Ocean model	MOM-3: 60N-65S 1/3 x 1 deg Assimilation depth – 750m	MOM-4 – fully global ¼ x ½ deg Assimilation depth – 4737m
Land-surface model (LSM) and assimilation	Climatology	Daily analysis and prognostic sea ice
Coupling freq	Daily	30 minutes
Data assimilation	Retrieved soundings, 1995 analysis, uncoupled background	Radiances assimilated, 2008 GSI, coupled background

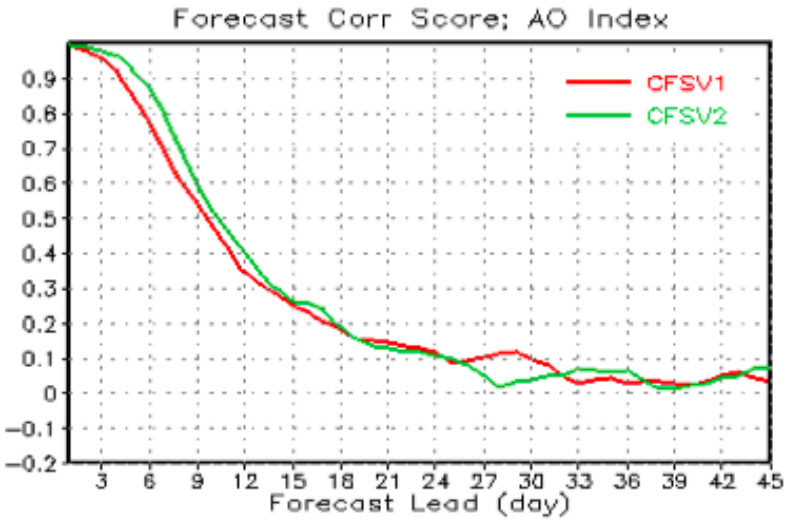
Assessment of MJO Prediction Skill

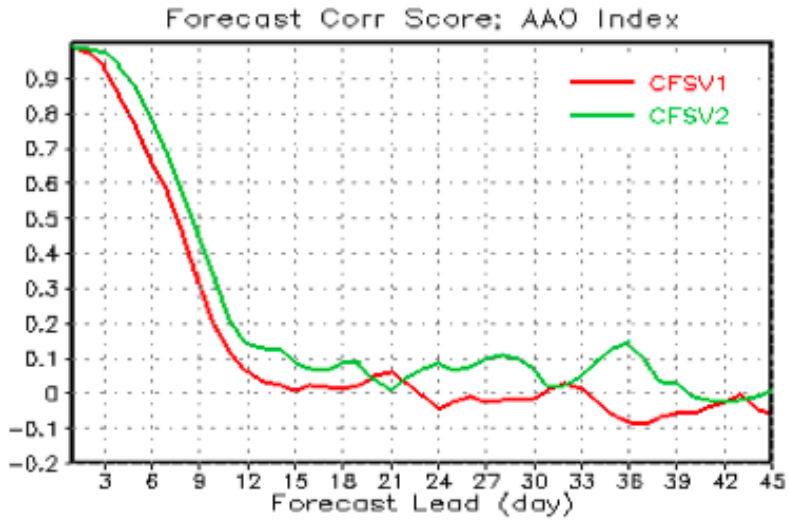


Anomaly Correlation for Atmospheric Indices







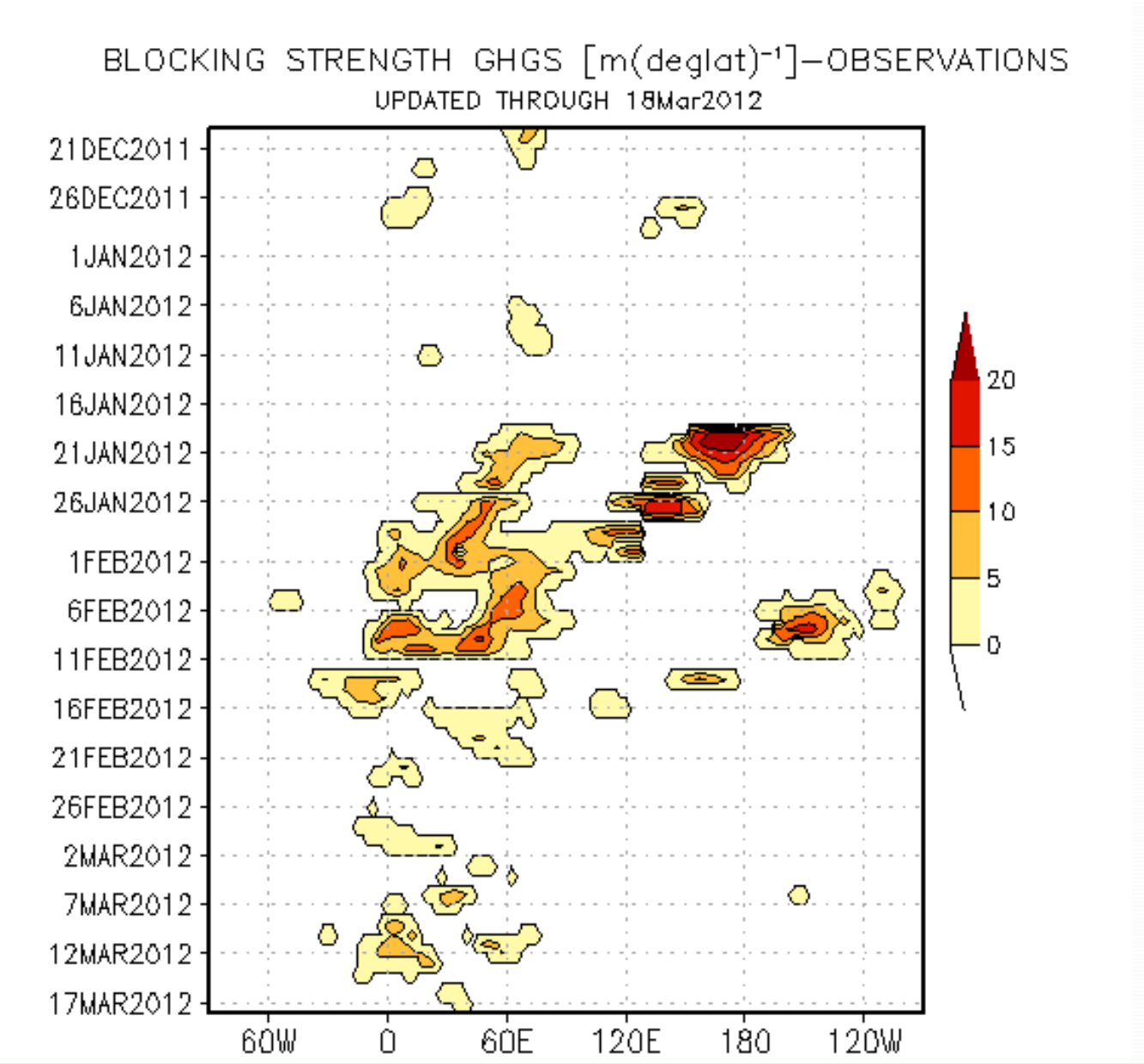


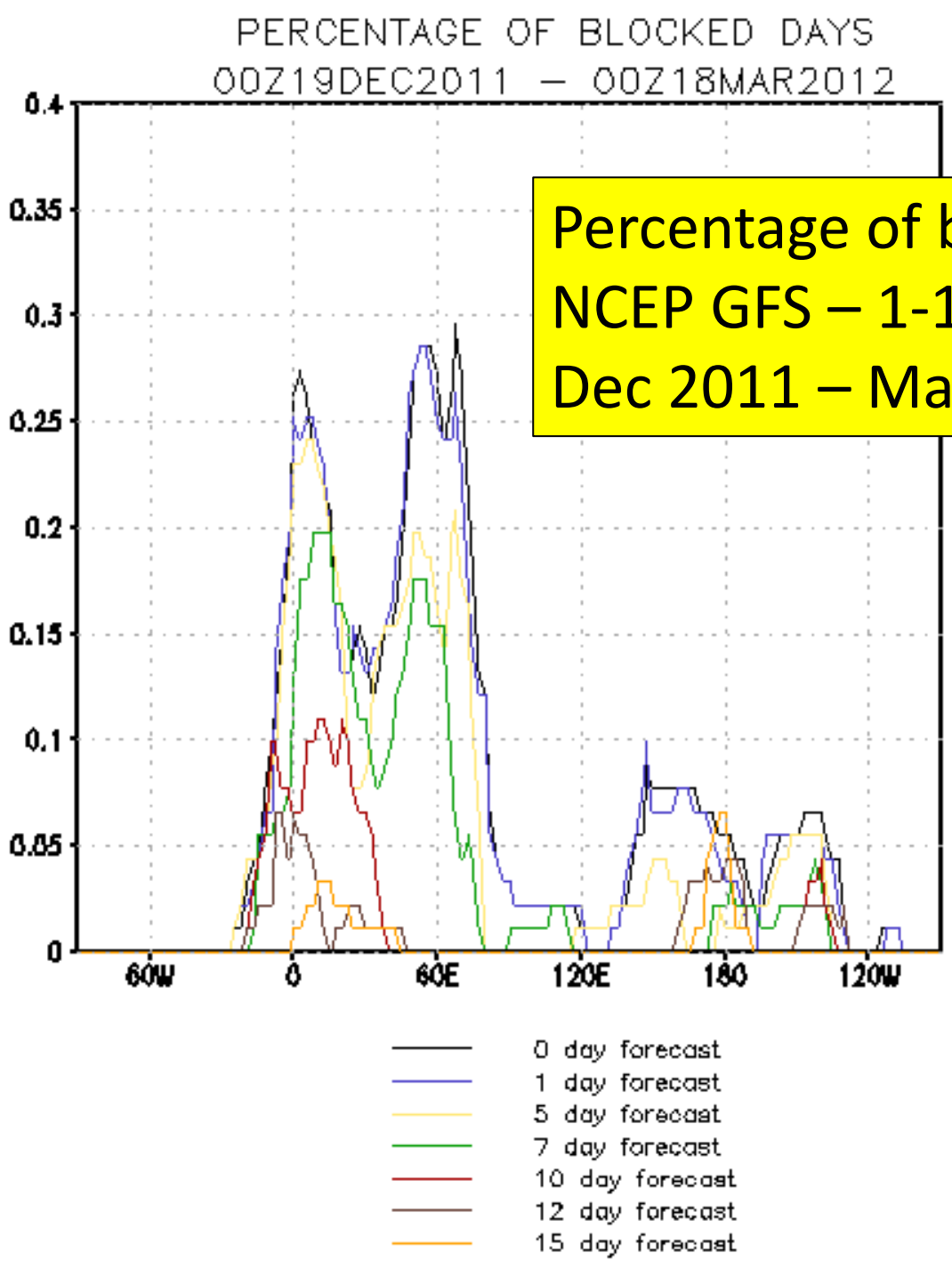
J. Schemm CPC/NCEP

Example of mergers of multi-agency components for earth system models

Attribute	CFS v2 Implemented March 2011	FIM – iHYCOM (in testing at NOAA/ESRL)
Analysis resolution	38 km (T382)	
Atmosphere model - resolution	100km (T126 – spectral) / 64 levs	Tested at 60km (icosahedral) / 64 levs
Model physics	Variable CO2 (specified) AER SW and LW radiation Prognostic clouds & liquid water Retuned mountain blocking Convective gravity wave drag	Same as CFS/GFS
Ocean model	MOM-4 – fully global ¼ x ½ deg - tripolar Assimilation depth – 4737m	HYCOM – global 60km icosahedral – matched with atmospheric grid
Land-surface model (LSM) and assimilation	Daily analysis and prognostic sea ice	Same as CFS
Coupling freq	30 minutes	Every time step
Data assimilation	Radiances assimilated, 2008 GSI, coupled background	FIM hybrid/EnKF testing underway using GSI/hybrid

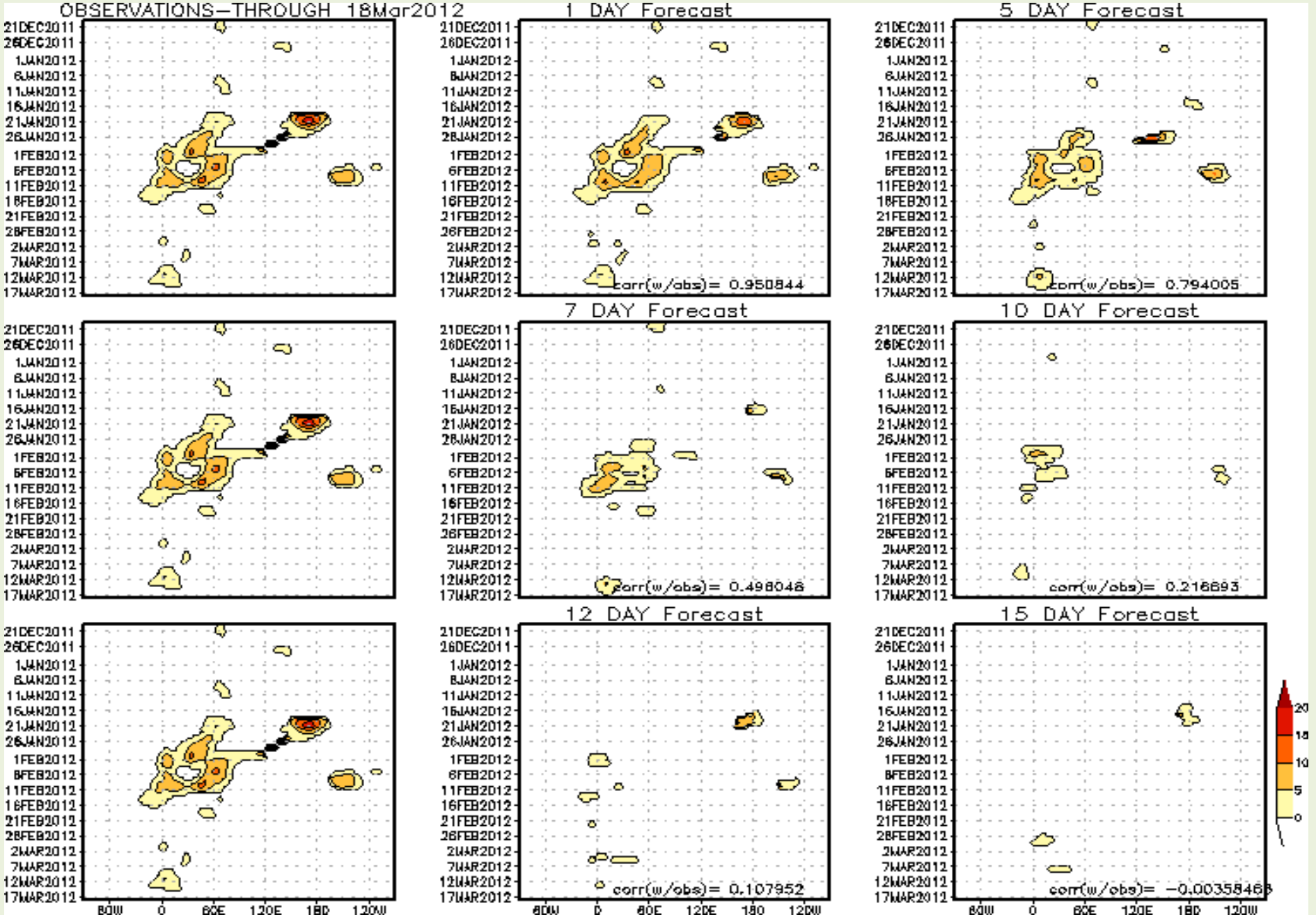
North American blocking index over last 3 months





Percentage of blocked days
NCEP GFS – 1-15 day fcsts
Dec 2011 – March 2012

Blocking Index – N.Hemisphere – Dec 2011 – Mar 2012



Sample earth system model products

- Fish and crustacean stock prediction
- Snowpack and river flow rates
- Toxic algal blooms
- Crop planting guidance
- Oceanic CO_2 sequestration via iron fertilization
- Navigability of Arctic Ocean
- Seasonal wildfire danger
- **Persistent stationary planetary waves**
- Coastal erosion (sediment transport)
- Seasonal tropical storm frequency
- Frequency of ozone violations

1-6 mo prob?	Components needed					
	ocean	Dyn ice	chem	Hydro	Dyn veg	Biogeochem
Y	✔		✔	✔	✔	✔
Y	✔		✔	✔		
Y	✔			✔		✔
Y	✔				✔	
N	✔	✔	✔	✔	✔	✔
N	✔	✔				
Y	✔		✔	✔		
Y	✔	✔	✔		✔	
Y		✔				
Y	✔		✔			
Y	✔		✔		✔	

ESPC demo target: improved 1-6 month fcst of blocking

Processes related to blocking onset, cessation, prolongation

- Extratropical wave interaction
- MJO life cycle
- Other tropical processes
- Tropical storms and their extratropical transitions
- Sudden stratospheric warming events
- Snow cover anomalies
- Soil moisture anomalies

Components needed

Initial value – data assim	High-res Δx	Coupled ocean	Stochastic physics	PV cons-numerics	Chem/aerosol	Soil/snow LSM accuracy
✔	✔		✔	✔		
✔	✔	✔		✔	✔	
✔	✔	✔	✔		✔	
✔	✔	✔	✔	✔	✔	✔
✔				✔	✔	
✔					✔	✔
✔					✔	✔